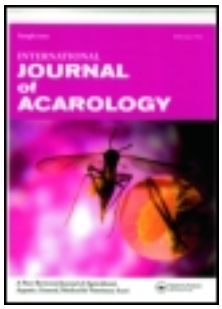

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Field efficacy of flumethrin pour-on against livestock ticks in Iran

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Ticks play an important role in the transmission of a variety of diseases in Iran. High prevalence of tick-borne diseases, such as relapsing fever and Crimean–Congo haemorrhagic fever (CCHF), has been reported in the study area. The aim of this study was to determine the field efficacy of flumethrin on mortality and deterrence of ticks on tick-infested livestock in Meshkin Shahr, Iran. Flumethrin was applied to the back of livestock at the rate of 1 ml/10 kg body weight and tick density was recorded for up to 2 months after application. The deterrent effect of flumethrin was also assessed on cattle sheltered in the same barn. A total of 3144 hard and soft ticks were collected from 300 cattle and 10% of them were identified. The main hard ticks include *Hyalomma marginatum*, *Hyalomma anatolicum*, *Hyalomma dromedarii* and *Hyalomma detritum* and the soft ticks comprise *Ornithodoros lahorensis* and *Argas persicus.* The treatment with flumethrin pour-on provided complete protection for 2 months. The density of ticks per head of cattle in the control group has not significantly decreased during the study period. This method of application is useful for livestock owners; government staff are not required for application and only community education and participation are needed. This pesticide's efficacy will reduce tick-borne diseases such as relapsing fever and Crimean–Congo haemorrhagic fever.

Keywords: flumethrin; ticks; livestock

Introduction

Many arthropod species act as vectors of different disease for animals and humans. Tick-borne livestock diseases (TBLDs), for example, Crimean–Congo haemorrhagic fever (CCHF), babesiosis, theileriosis, anaplasmosis, endemic relapsing fever, Lyme's disease, tularemia and Q fever, cause economic losses to the livestock-breeding industry annually. The epidemiological features of TBLD include that they are quick spreading and cause severe epidemics among livestock in a short time, which makes them a serious risk for human communities. For this reason, surveillance, elimination, control and investigation of TBLD have high importance throughout the world. Several methods including dipping, residual spraying, powdering and insecticide application to livestock bodies as pour-in and spot-on formulations have been developed. There are several ectoparasites on animals such as lice, mites, ticks, houseflies, blowflies, botflies, horseflies, horn flies, sandflies, tsetse flies, blackflies and mosquitoes.

There are several studies on the biology, distribution and systematic and medical importance of hard and soft ticks for relapsing fever and CCHF in Iran (Arshi et al. 2002; Vatandoost et al. 2003; Telmadarraiy et al. 2004, 2007a, 2007b, 2010; Aghighi et al. 2007; Salari Lak et al. 2008; Masoumi Asl et al. 2009; Kia et al. 2009, 2010; Salimabadi et al. 2010). Several insecticides, including organophosphate, carbamate, pyrethroid and insect growth regulators, are used for the control of ectoparasites of livestock in the country (Mohebali et al. 2009). The main method of application of pesticides against ticks are dipping method, pour-on and sometime oral administration by systemic acaricides. According to the report of the Meshkin Shahr Health Center, the tick-borne diseases among livestock in the Meshkin Shahr in 2008 are: CCHF disease among animals 39%, theileriosis 5–10% and babesiosis 22–30%.

Flumethrin is a type II synthetic pyrethroid used as an ectoparasiticide, and in veterinary management it is applied topically on cattle, goats and sheep as a 1% weight/volume pour-on for the control of ticks, lice, mites and nuisance insects. Flumethrin is used because of the high susceptibility of ticks to it, its killing and repelling effects, its effect on various ectoparasites, considerable residual effects, rapidity of action and people satisfaction. The oral 50% lethal dose (LD_{50}) for rats is 500–1000 mg/kg and dermal LD_{50} is more than 5000 mg/kg. The mode of action of flumethrin is on the ectoparasite nervous system. It disturbs axonal impulse conduction in the central and peripheral nervous systems by changing the K^+/Na^+ permeability and producing marked overexcitation followed by paralysis and death of the ectoparasites.

The aim of this study was to evaluate the efficacy of flumethrin pour-on for the control of hard and soft ticks in a major cattle-breeding province of Iran, Ardabil Province where there are several reports on relapsing fever and CCHF (Majid-pour 2003; Masoumi Asl et al. 2009; Oshaghi et al. 2010).

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Materials and methods

Study area

Ardabil Province is located in north-west Iran at 38°15′05″ N, 48°17′50″ E. This province has a total area of 18,634 km^2 and is divided into two geographical parts, mainly mountainous and one-third as plateau (see Figure 1). The study was carried out in Meshkin Shahr during 2009–2010.

Random sampling of livestock

In the study area, two villages with the same epidemiological characteristics were selected and the stables were chosen randomly. Mijandi district was considered as the control area and Oor-kandy as the intervention area. The distance between two areas is around 2 km. Each head of livestock was tagged and followed for tick infestation during the study period. In the treatment area, 100 head of livestock were treated with flumethrin and 100 adjacent livestock were followed for the evaluation of the repellent effect of the pesticide. For control groups, another 100 livestock were chosen and the density of ticks was calculated. Total livestock in the area is calculated as 287,580 and the range of livestock per family is between 1 and 100. Flumethrin pour-on was applied to the treatment group according to the manufacturer's recommendations, that is, along the dorsal mid-line from the head to the base of the tail. Flumethrin with its trade name of Bayticol® Pour-on (Bayer AH, Meshkin Shahr Health center, Ardebil

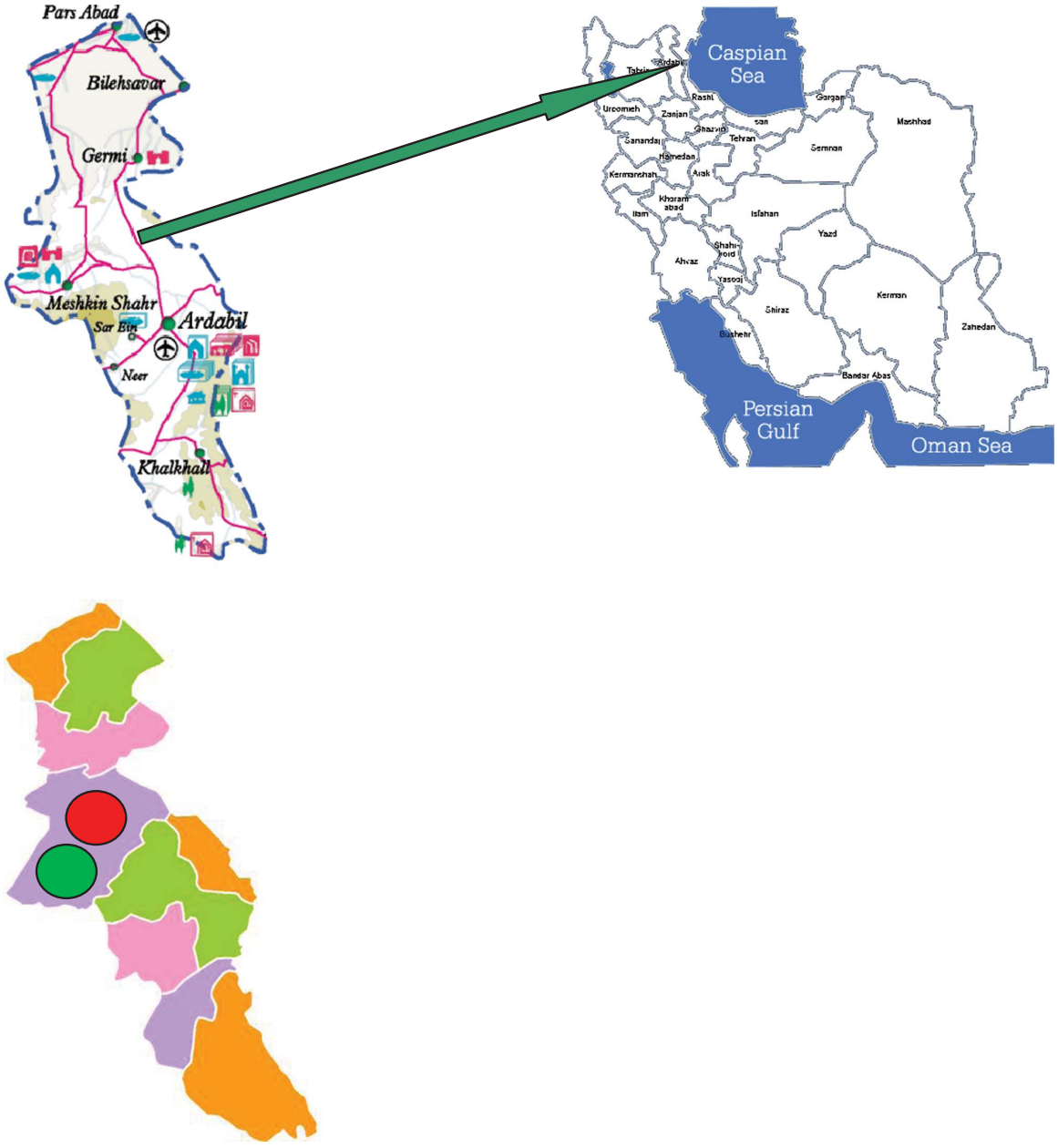

Figure 1. Map of the study area in Meshkin Shahr, Ardabil Province, Iran. The red circle indicates the intervention area and the green one indicates the control.

province, Iran) and chemical name of cyano(4-fluoro-3-phenoxyphenyl) methyl was provided by the regional health centre. According to the recommendation of the company, the basic dosage is 1 ml/10 kg body weight of sheep and goats and 2 ml/10 kg body weight of cattle and oxen.

Tick collection and identification

Tick collections were carried out on domestic ruminants. Ticks were collected from sheep, cows, goats and buffalo. The following equipment was used for tick collection: aprons and overalls, forceps, thermometer, hygrometer, torch, test tube, boots, latex gloves, disposable mask, cotton wool, ethanol, labels, cattle holder, cattle ear tag, painting spray, marker, notebook, towel, test tube rack and global positioning system. The collection method was in accordance of standard method as described by WHO.

The collected specimens were transferred into holding tubes and counted, and then were identified using morphological characteristics and the key identification guide (Kaiser and Hoogstraal 1963).

Statistical analysis

Different statistical parameters, such as mean, standard deviation and standard error, were used for the results. The statistical analysis was carried out according to the relevant data such as *t*-test, Chi-square test and paired *t*-test at the 5% confidence intervals. The significant difference was measured when $P < 0.05\%$.

Results

The efficacy of a flumethrin pour-on was evaluated in natural infestations of ticks on livestock in two villages in Meshkin Shahr, Ardabil Province, Iran during 2009–2010. The livestock were heavily infested with soft and hard ticks. Killing and deterrent effects of the flumethrin 1% pour-on were applied against livestock ticks at 1 ml/10kg. In all, 300 head of livestock were selected, comprising cattle, buffalo, sheep and goats in two villages with similar conditions; of these 100 and 200 head of livestock were allocated as the control and intervention groups, respectively. The age groups of the livestock are also shown in Figure 2.

Figure 3 indicates the tick infestation rate among livestock in control area. The main indicator was the number of surviving ticks. Other factors such as sex and age of livestock, season of insecticide application and residual periods of flumethrin were considered. During the study period a total of 3114 ticks were collected randomly and identified. The hard ticks comprise 75% of the collected ticks and the remainder were identified as soft ticks. Species composition of hard ticks on livestock comprised: *Hyalomma marginatum*, *Hyalomma anatolicum*, *Hyalomma dromedarii*, *Hyalomma detritum* and *Rhipicephalus bursa* in the studied villages. Also two species of soft ticks, *Ornithodoros lahorensis* and *Argas persicus* were collected.

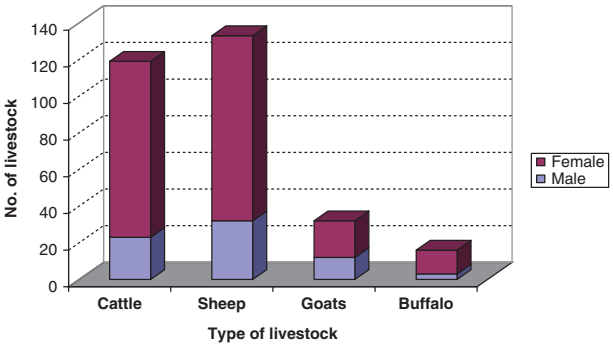

Figure 2. Sex ratio of different livestock collected during study period in Meshkin Shahr, Iran.

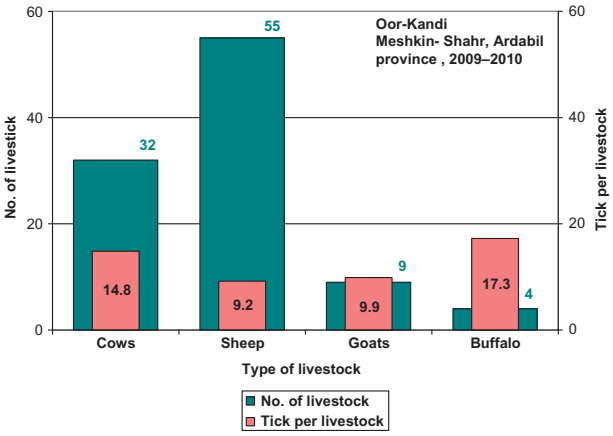

Figure 3. Tick infestation rate among livestock in control area in Meshkin Shahr, Iran.

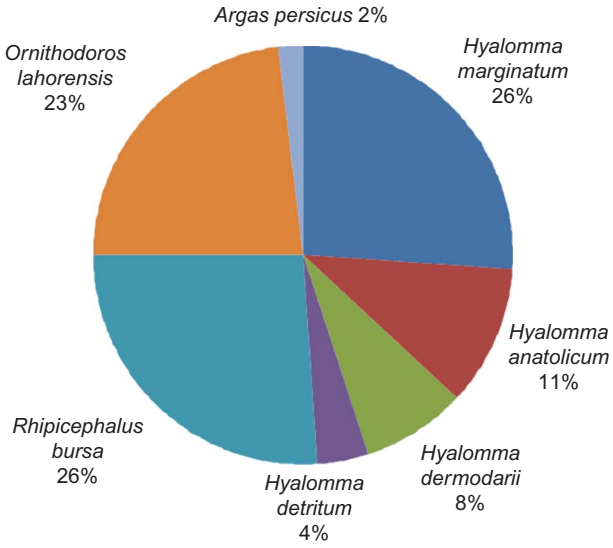

Figure 4. Species composition of sampled ticks on livestock.

The percentage of main hard ticks and soft ticks is shown in Figure 4. The composition of tick species in control and treatment areas is shown in Figures 5 and 6, respectively.

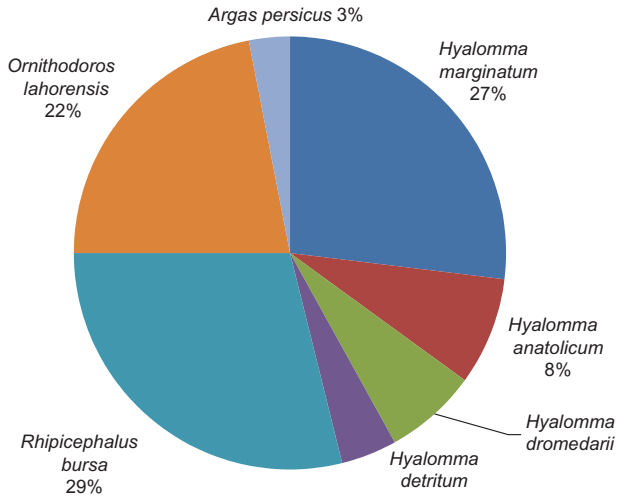

Figure 5. Tick species composition collected in control area of Meshkin Shahr, Iran.

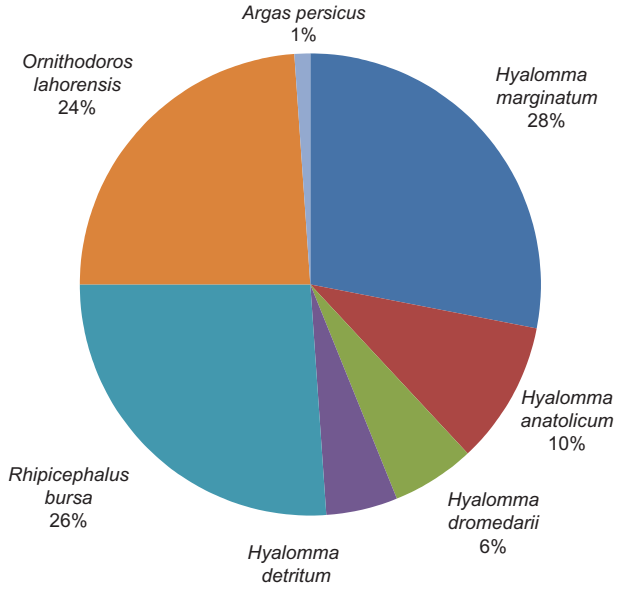

Figure 6. Tick species composition in intervention area in Meshkin Shahr, Iran.

The original pictures of ticks are shown in Figure 7. The results showed that among ticks *H. marginatum* has the high density and *H. anatolicum* and *H. dromedarii* have the least frequency. Among soft ticks *O. lahorensis* comprises the highest prevalence. Tick infestation among different types of livestock before application of flumethrin is shown in Figure 8.

Assessment of killing effects of flumethrin against ticks on different livestock age groups resulted in non-significant differences of surviving ticks between post-treatment times ($P > 0.01$), but the surviving ticks were significantly different on pre-treatment day compared with 1 day, 2 days, 3 days, 1 week, 2 weeks, 1 month and 2 months ($P < 0.01$) (see Figure 9).

The surviving ticks did not significantly alter during the 2 months of evaluation in the control group. The surviving ticks reached 5.0–16.0% after 1–2 days after treatment in treated livestock, which equals 84.0–95.7% mortalities. The residual period of flumethrin was estimated to be 2 months on livestock with 99.0% efficacy against ticks. The efficacy of flumethrin did not differ among different types of livestock (cattle, buffalo, sheep and goats).

The deterrent effect of flumethrin on treated livestock was considerable on untreated livestock kept adjacent to treated livestock. This phenomenon reached its highest level during the second week after treatment and continued to the eighth week ($P < 0.01$) (see Figure 10).

Discussion

Before application of the flumethrin, the average number of ticks per head of cattle was around 11 ± 2. Treatment by flumethrin exhibited that tick density fell 1 day after application. The reduction rates for ticks after 1, 2 and 3 days application were 84.24%, 95.78% and 98.42%, respectively. After 1 week the density of ticks had fallen to nearly 0 and the trend of reduction had been extended by up to 2 months. The density of ticks per head of cattle also declined on the adjacent livestock, which are living in the same stable as the treated animals, indicating the deterrent effect of the pesticides. The reduction rate of ticks after 1, 2 and 3 days on the adjacent livestock were reduced to 14.68%, 34% and 55.39%, respectively. The reduction rate was 72.57% and 82% after 1 and 2 weeks of application, respectively, and after 1 and 2 months, the rates were 91.25% and 95.68%, respectively. This shows that flumethrin has an additional repellent effect against ticks. There is no significant tick reduction in the control group before and after 2 months of study period ($P > 0.05$).

In our study, the efficacy of flumethrin as a pour-on formulation was evaluated against ticks on livestock in two villages in Meshkin Shahr, Ardabil Province. The treatment provided a complete protective period of 2 months against different ticks, both soft and hard. The insecticide has an additional repellent effect against ticks. The livestock treated with flumethrin did not show any adverse reaction.

There are several reports of efficacy of flumethrin for tick control as well as nuisance insects on animals worldwide (Hamel 1987; Liebish and Beder 1988; Bauer et al. 1989; Werner et al. 1989; Löhr et al. 1991; Duncan 1992; Gouteux et al. 1996; Garg et al. 1998; Shimizu et al. 2000; Alahmed et al. 2001; Fourie et al. 2001, 2003). The efficacy of a flumethrin 1% pour-on (Bayticol, Bayer AH (Veterinary Unit, Meshkin Shahr)) was evaluated against natural tick infestations on cattle on a dairy farm in Ethiopia during 1997–1998. A rapid kill 24 h after treatment and 100% control from day 4 onwards was achieved and maintained for a further 29 days (Mekonnen 2000).The efficacy of flumethrin recorded by Tuzer and Tinar (2008) against *H. anatolicum excavatum*, *H. marginatum marginatum* and *Boophilus annulatus* was significant and they reported a protective period of 5 weeks for tick control on cattle. Exposure of *H. dromedarii* to flumethrin reduced the

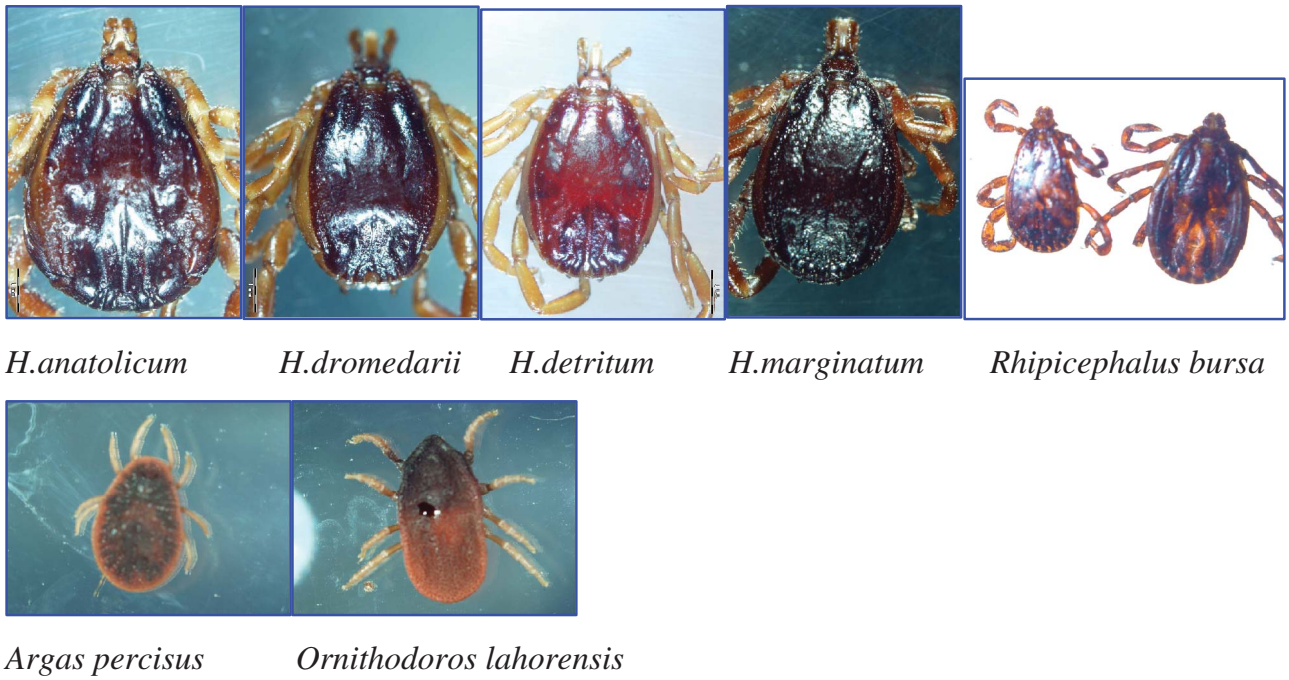

Figure 7. Pictures of collected ticks including hard and soft during study period in Meshkin Shahr, Iran.

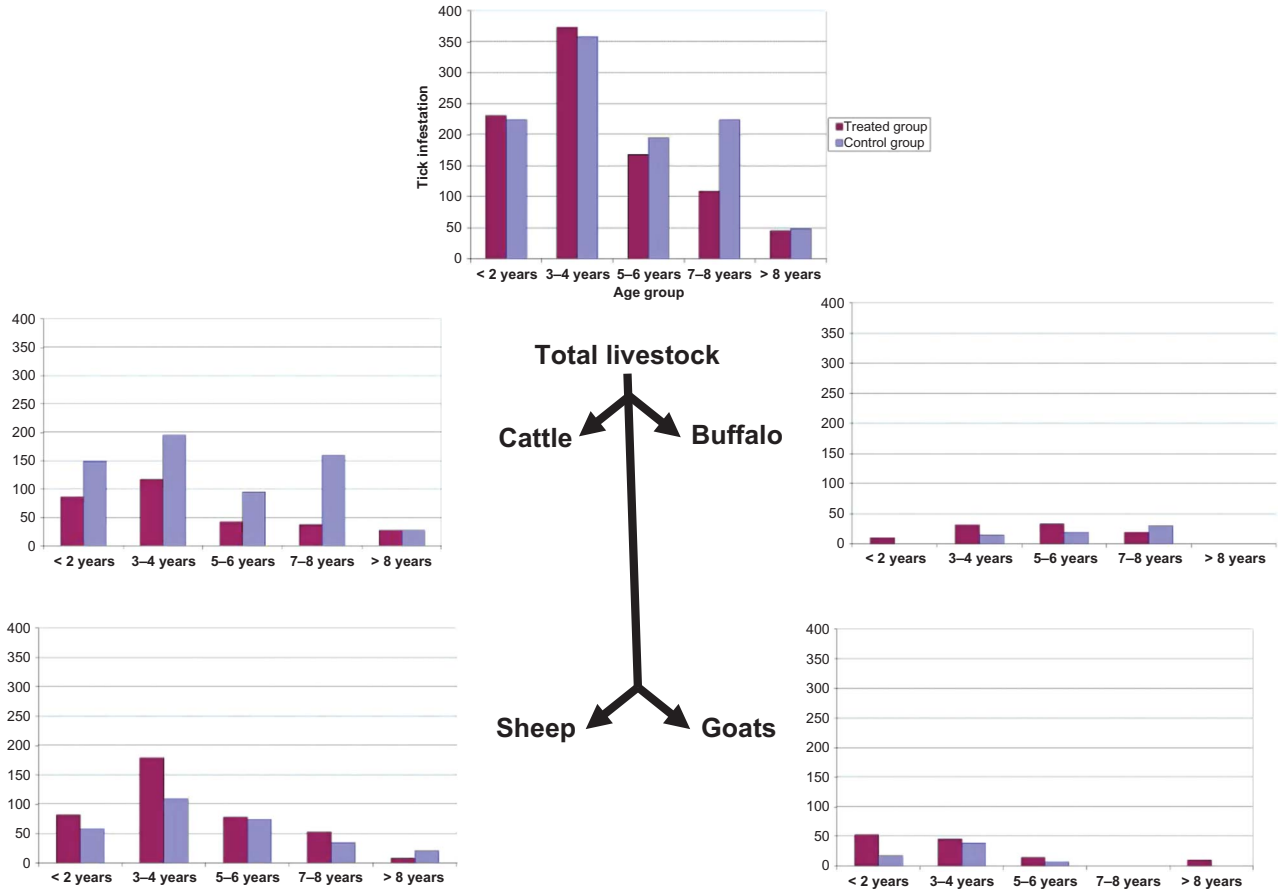

Figure 8. Tick infestation among different types of livestock before application of flumethrin.

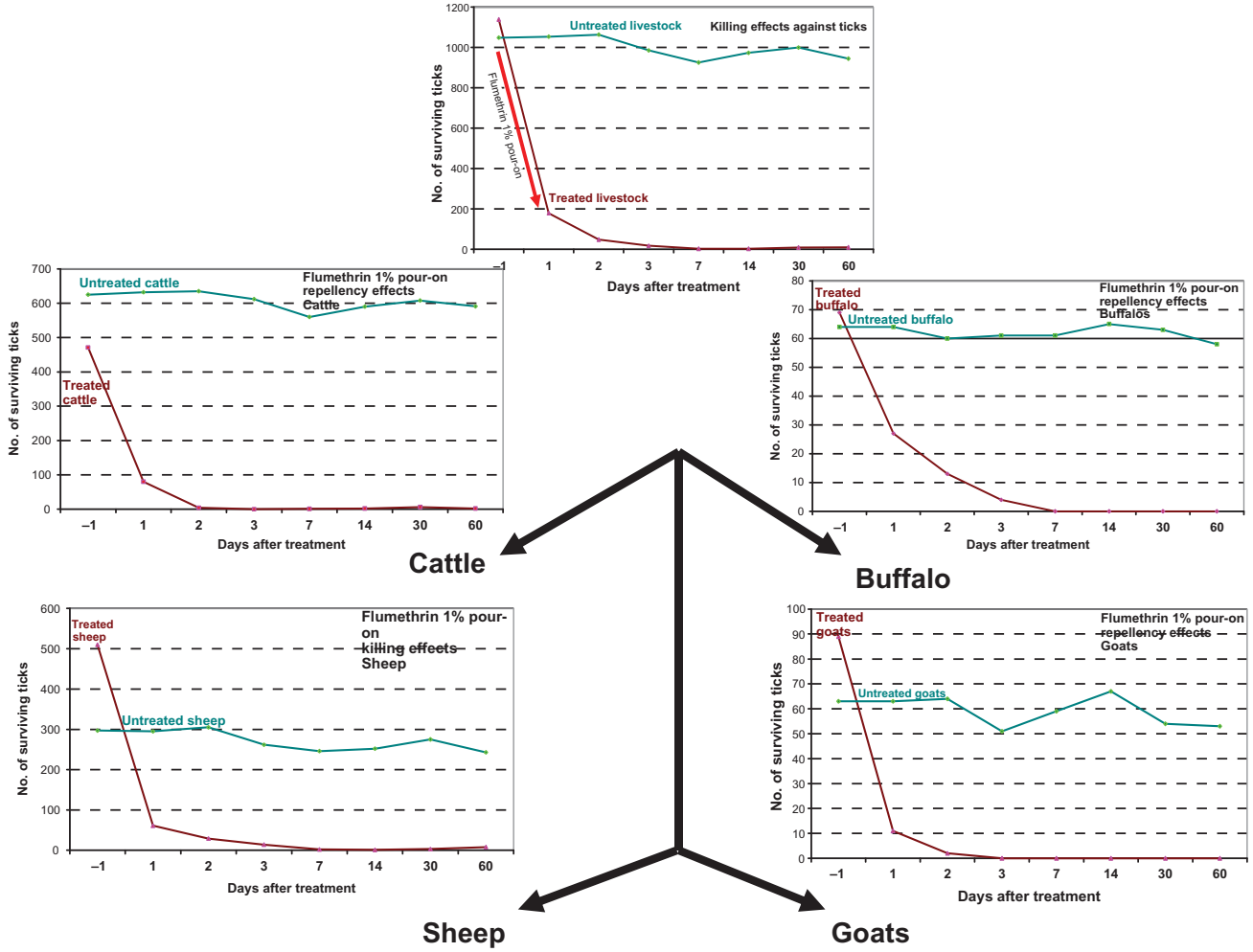

Figure 9. Tick mortality rate among different types of treated livestock compared with untreated group in Meshkin Shahr, Iran ($P < 0.05$).

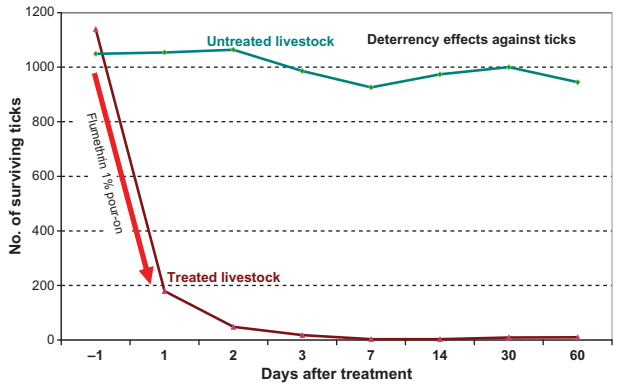

Figure 10. Deterrent effect of livestock which adjacent with flumethrin treated livestock compared to untreated group in Meshkin Shahr, Iran ($P < 0.05$).

percentage of females ovipositing, the egg mass weight and number of eggs (El-Azazy and Lucas 1996).

The trial results demonstrate clearly that this new method of tick control can be effectively applied in commercial and traditional cattle husbandry. Monitoring and evaluation of insecticides in terms of their efficacy and possible resistance to them is highly recommended. Resistance and the genetics of resistance for this agent have also been reported. Tapia-Perez et al. (2003) found that resistance was almost dominant at the lowest dose and almost completely recessive at the highest dose. Maternal effects were shown for egg mass. The results shown here indicate more than one gene basis of flumethrin resistance in *Boophilus microplus* ticks.

In this study, the residual effect of flumethrin 1% pour-on on livestock was 2 months. Hamel (1987) reported a 4-week residual effect in Namibia. Werner et al. (1989) reported 13 days in Mongolia and Shimizu et al. (2000) recorded 1 month in Japan. Tuzer and Tinar (2008) reported 3–8 weeks. We recommend further laboratory and field assessments of inhibition by flumethrin of blood feeding by ticks; assessment of sublethal dosages of flumethrin from point of inhibition of oviposition, decrease of potential of egg laying, egg hatching and different developmental stages of ticks; and assessment of miticidal effect of flumethrin on livestock. The acceptable daily intake for flumethrin is considered to be 0–0.004 mg/kg and maximum residual

level is 108 μg/day. However, assessment of the flumethrin residue in milk, meat and drinking water of livestock is recommended.

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